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# FLOOD CONTROL OF THE MISSISSIPPI RIVER

ADDRESS

BY

COL. C. McD. TOWNSEND
UNITED STATES ARMY

AT

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# FLOOD CONTROL OF THE MISSISSIPPI RIVER.

Mr. President and gentlemen, when such a disaster occurs as has swept over the Mississippi Valley within the last few months, it arouses the intellectual activity of our people, and many suggestions are made of the means of preventing its recurrence.

As president of the Mississippi River Commission, I have received numerous communications, some addressed to the President of the United States, the Secretary of War, or the Chief of Engineers, attempting to explain the causes of this great flood, or giving the writer's views of the mistakes which have been made by the Mississippi River Commission in handling it.

The Mississippi River Commission has explained with great detail in its reports its reasons for relying on levees for protecting the country from overflow, but they appear to be unknown, not only to the country at large but to many who reside in the Mississippi Valley and are most vitally interested in the problem.

I therefore consider it proper to appear before you, accept the invitation of the illustrious speaker who preceded me, and state briefly reasons for rejecting the various methods of flood control, other than levees, which have been suggested. As a full discussion of any one of the propositions would prolong my remarks to such an extent as to tax your patience, I can only touch upon the subject, and I have confined myself to stating not what I considered the most logical argument for the engineer, but the reason most evident to the general public for rejecting a proposition.

## ABANDONMENT OF LEVEES.

Many persons in the United States—some even in the Mississippi Valley—argue that as the heights of floods have increased as the land has been reclaimed, this is sufficient evidence that there are no limits to the heights which the river will reach, and that levees should therefore be abandoned, mounds constructed to preserve cattle and other farm animals during the floods, and the cultivation of the country confined to such periods as there is no overflow. Such critics point to the Nile as an example, and argue that as this method of handling the Nile has been successful, it should be applied on the Mississippi.

I shall discuss the question of levee heights later, but desire at the present time to particularly invite attention to the dangers which result from comparing one river with another without familiarity with the conditions that exist on both.

It is unquestionably true that the flood waters of the Nile have for ages been permitted to spread over its valley with beneficial results, but it by no means follows therefrom that other rivers should be similarly treated.

The Nile rises near the Equator, and flows from a tropical toward a temperate zone. This characteristic differentiates it from most of the other large rivers of the world. Its floods arise from tropical storms during the early winter months, which reach its mouth early in the spring. It therefore deposits its silt on the land and subsides before the agriculturist is prepared to plant his crops. In fact, as there is little rain in the Nile Valley, it is impossible for the crop to grow until the river overflows.

The conditions on the Mississippi are the reverse. Its sources are in the ice-bound North, and it flows toward the Tropics instead of away from them. The snows at some of its sources are beginning to melt when the floods of the Nile have reached the sea. Bounteous rains occur in the lower valley, and the crops are therefore well advanced before the flood arrives. The floods of the Nile prepare the land for the farmer, while those of the Mississippi destroy the crops he has planted.

An occasional flood from the Cumberland and Tennessee Rivers may flow down the river and subside in time to allow planting after it has passed, but the usual flood from the Ohio River, and any flood from the Missouri or upper Mississippi Rivers arrives so late that it is impracticable to raise cotton or sugar cane after it subsides.

As Judge Taylor has observed, if the river was allowed to disperse its waters freely over the whole alluvial plain, the overflow would be shallow, and low mounds would suffice for refuge during floods where the inhabitants could wait in safety for the waters to subside.

Men have lived and could live again under such conditions, but not comfortably, according to modern ideas. Such abandonment of all attempts at control of the river would leave it free to work its own will on its banks. It would wander hither and thither around sand bars which it had built from material taken from its caving banks and which it would be unable to remove. It would behave as it did in the ages when it was building the alluvial valley. The same law of sedimentary deposit which obtained then would be present and controlling. A narrow margin of land adjacent to the overflow would be built up, beyond which would stretch interminable swamps filled with water. No intelligent man can entertain seriously such a proposal as this.

## REFORESTATION.

Judging from my correspondence, it would appear that there exists in the public mind an impression that the prime cause of floods in this country has been the destruction of the forests, and that the surest way to prevent them is by reforestation. The subject of the influence of forests on stream flow is not unknown to the river engineer. It has been extensively discussed both by European and American engineers since Gustav Wex, imperial and ministerial counselor and engineer of the improvement of the Danube River at Vienna, in 1873, submitted a series of papers on the decrease of water in springs, creeks, and rivers, which were translated into English by the late Gen. Weitzel, of the Corps of Engineers.

There is a great diversity of opinion on the subject, some maintaining that the cutting off of forests will ultimately convert Europe into a Numidian desert, while others claim that a moderate cutting of the

forests even increases the rainfall. Whatever may be the theoretical principles involved, their practical application to the lower Mississippi River is fraught with great difficulty.

When a country acquires a population of nearly 100,000,000 people, the forest primeval which existed when it was first settled has to disappear. It is all very well to bemoan the fact that if the black walnut which once covered the State of Ohio had not been destroyed and was sold as lumber at the present market rates it would equal the assessed valuation of the property of the State, but there have now been created the cities of Cleveland and Cincinnati, whose people can not live on black walnuts alone, but require grain and meat. The black walnut of Ohio has gone never to return, and it is the same in other sections. The fertile lands will not be taken away from the farmer. They are too valuable for raising potatoes and hogs. Only the poorer soils can be used for forest culture, and only a limited reforestation then is possible. It is therefore ridiculous to expect any better results in reference to floods from reforestation than existed before the forests were destroyed. While our official gauge records do not in general extend back much more than 40 years, yet on several of the western rivers we have records of the heights of floods extending over a century. Thus at St. Louis there is a flood recorded in 1844, having a height of 41 feet on the gauge. The next highest flood, in 1785, was over 40 feet. At Cincinnati in 1832 there was one of 64 feet. It is needless to explain to this audience that a flood of such heights in either the Ohio or upper Mississippi would mean ruin to the plantations below Cairo if there were no levees to protect them.

It is, however, argued by some that with reforestation if the floods occasionally were high they would not be as frequent. Again let us search the records of the past. It is hopeless by reforestation to expect to reproduce the forest growth that existed at the close of the Civil War. Yet from 1857 to 1867 was a most remarkable series of great floods, occurring as frequently as any that have been recorded since that time.

## RESERVOIRS.

Next to reforestation, reservoirs as a means of controlling floods appears to have the most advocates. The reservoir theory is particularly attractive, as we have before us in the Great Lakes a practical illustration of flood restraint by means of natural reservoirs. Reservoir control of the Mississippi River was discussed by Humphreys and Abbot in 1858, and on the upper Mississippi the Corps of Engineers has constructed the largest system of reservoirs for regulating rivers that has been built in any country, having nearly twice the capacity of those proposed by the Pittsburgh flood commission for controlling floods at Pittsburgh. These reservoirs have been most successful, not only for increasing the low-water discharge of the Mississippi River above St. Paul, the purpose for which they were constructed, but also for reducing floods in that portion of the river.

There is therefore nothing novel to the river engineer in the proposition to control rivers by reservoirs. We have not only studied its advantages, but we know its limitations. Conditions are extremely favorable for reservoir construction at the headwaters of the Mississippi, but while they materially increase the low-water discharge at St. Paul and markedly reduce flood heights, yet 100 miles farther

down the river it is impossible to detect their influence during either high or low water.

A reservoir must be close to the locality to be benefited or its value rapidly diminishes, and this is a serious trouble with any project for regulating the lower Mississippi by reservoirs.

The material which is eroded from our hills is carried down by our rivers and deposited during floods on the lowlands of the lower reaches, making them the richest agricultural portions of our country. They become highly cultivated, buildings and fences are constructed, towns spring up and are connected by highways and railroads. Railroad wrecking is a rather popular amusement at present, so I omit their relocation from the discussion; but the engineer had better beware of that horny-handed son of toil, the American farmer. He is not going to consent to be driven from the rich alluvial valley to the less fertile hills, and is going to protest most vigorously against structures which will cover his fields with water from 150 to 200 feet deep. As he has votes, it is going to be necessary to listen to him, and the dams must be moved back to the mountain streams where land is of little value. This renders necessary the construction of the reservoirs to control the Ohio River on the upper branches of the Allegheny, Monongahela, and other tributaries, over 1,000 miles from its mouth. Those on the upper Mississippi will also be about 1,000 miles from Cairo, and those on the Missouri over 2,000. These are too great distances for the proper regulation of any stream. Moreover, such a project leaves too large a proportion of the watershed unprotected to be effective. In fact, the flood of 1912 was caused by rains in that portion of the valley which would be without reservoirs. It was not the melting snow at the sources, but rains in midstream areas that created the damage. Neither at Cincinnati, St. Louis, Chattanooga, or Nashville were flood heights excessive.

I have recently been appointed a member of a board to investigate the use of reservoirs to protect the city of Pittsburgh from overflow. The Pittsburgh flood commission has a carefully prepared project which proposes to store in 17 reservoirs 59,000,000,000 cubic feet of water at an estimated cost of about $21,000,000, which I consider very reasonable. Fifty-nine thousand million is a pretty large looking figure, but I made a little computation to see what it meant when translated into a unit applicable to the Mississippi River, and found that during less than seven hours 59,000,000,000 cubic feet of water flowed by the latitude of Red River at the crest of the recent flood, and, based on the estimate of the flood commission, it would therefore require over $73,000,000 to build reservoirs that would hold the water that passed down the river in one day. The cost of storing one day's flow is ample for all the levee construction required on the river, while if reliance is placed on reservoirs, provision must also be made for the other 48 days the river was above a bank-full stage.

## CUT-OFFS.

Another favorite method suggested for reducing flood heights is by means of cut-offs. The Mississippi River Commission in numerous reports has called attention to the injury which would result from cut-offs, the increased caving which is caused thereby, and the

damage to navigation during low water. These may be thought by some theoretical considerations. I desire to invite attention to the fact that cut-offs have been repeatedly tried in Europe as a means of reducing floods, but always with disastrous results. The most noted example is the river Theiss in Hungary.

This river originally had a very gentle slope, about equal to that of the Illinois River below La Salle. It was leveed with the same results which always obtain when rivers are confined—the heights of its flood increased. It was then proposed to shorten the river by cutting off the bends and thus giving it a deeper slope. The project was carried out, but the first great flood that occurred after the work was completed rushed through the improved section much faster than the lower part of the river could carry it off. Flood heights were lowered, to be sure, at the upper end, but correspondingly increased at the lower, and in 1879 the town of Szegedin was destroyed by the flood.

At the Canal de Miribel on the Rhone a similar method was tried, with similar results. At the upper end of the reach both the high water and the low water planes were lowered, with great damage to the low-water navigation, while at the lower end they were raised, producing increased flood heights and also injury to the low-water channel. A cut-off affords relief at one locality, but at the expense of another.

## OUTLETS.

Outlets have been suggested as another means of relief, and the Mississippi River Commission has frequently discussed the inadvisability of outlets and waste weirs as a means of lowering flood heights. I differ with some of my conferees on this subject, but rather in the line of argument than in results. Where the river has depths exceeding 100 feet, as in the vicinity of New Orleans, I am of the opinion we could afford to permit a moderate diminution of river depths if thereby we could obtain a material reduction of levee heights. I also believe that the effect of outlets in reducing flood heights is not as great as is popularly supposed. The last flood, however, clearly demonstrated that wherever there was a large crevasse, which is but another name for an outlet, the river ceased to rise. Such outlets were not entirely satisfactory to the planter whose land was behind them. And another lesson to be derived from this flood is that if you are going to reduce flood heights by this means, you must also control your outlet, i. e., it will require a levee system of the same height as that of the main river, and the amount that is saved in the height of the levee line will not compensate for the extra length it is necessary to construct and maintain.

Another serious objection to an outlet is the difficulty in regulating the velocity with which the water will flow through it at varying heights of the main stream. If it is so constructed that it will discharge at a greater velocity than the river itself, there is danger of its enlargement to such an extent as to divert the greater part of the flow down it, and transfer the main stream itself into an outlet; and if, on the other hand, it discharges at a lower velocity, it will tend to fill with sediment.

## THE EFFECT OF LEVEES ON RIVER BED.

There is considerable confusion in the public mind in reference to the effect of levees on the river bed, some believing that they cause the bed to scour out, while others are equally as positive they cause the river bed to rise.

The motion of sediment in a silt-bearing stream is not clearly understood, even by many engineers who write on river hydraulics.

In such a stream there are certain sections called pools, which are usually found in the bends. These are separated by shallower sections which are called bars.

When the river is low the velocity with which the water flows through the pools is less than that with which it flows over the bars, and there is a tendency for the channel over the bars to scour out and the material eroded to be deposited in the pool below. As a river rises the velocity in the pools increases more rapidly than on the bars, and a period soon occurs when there is a greater scour in the pools than on the bars, so that the bars begin to rise and the pools to deepen. When the river falls the velocities in the pools decrease more rapidly than on the bars, and there is a reversal of the process—the bars deepening and the pools filling up. This action is modified by a movement of sand waves down the river and by a centrifugal force which results from the piling up of water in the bends, but it occurs in all alluvial streams which flow with sufficient velocity to scour their beds, whether they are leveed or not. Levees may, to a certain extent, intensify this action, but they will not materially change it.

With such constant mutations the only way to determine whether the river bed is rising or being scoured out is by comparing corresponding low waters with each other, or corresponding high waters.

Several hundred years ago a French traveler visited Italy, and on his return reported that levees had raised the bed of the Poe River. His statement was carefully investigated and found to be untrue, but, like Wex's assertion that the cutting of forests has injured river beds, it has traveled over the whole world where rivers have been improved, and vexed the engineer in charge of their improvement.

The French engineers have made careful investigations of the leveed rivers of France and found no evidence of such action. The Germans have studied the Rhine and the Austrians the rivers of Austro-Hungary and failed to detect it. The Mississippi River Commission has made similar observations of the Mississippi River and found more evidences of a scour than of a fill. In no case has it been observed that the effect of levees to raise the river bed was more than a few tenths of a foot in a hundred years, and may be termed a geological effect resulting from the lengthening of the river as it deposits its silt at its mouth. The assertion is now admitted to be false on the main rivers of all civilized countries which are capable of being studied, but it is still claimed that it is true in China and Japan. I recently visited Japan and had an opportunity to further investigate the subject. On the larger rivers, like the Osaka, there were no evidences of any such action, but in mountain streams which flow down steep hillsides and suddenly change their slope when they pass through plains, as is the case with a number of streams which empty into Lake Biwa, the upper portions of the streams have been scoured out, forming deep gullies, and the material thus eroded deposited at the foot of the hills. The

same conditions exist on the mountain streams which empty into the Mississippi that are not leveed, but the eroded material has an opportunity to spread over a greater area at the foot of the hills and is therefore not as perceptible.

My own view of the effect of levees on stream flow is that they tend to remove irregularities and make the slope more uniform. If a cut-off should occur, disturbing the river's regimen, they would tend to cause the river to return more quickly to its normal slope, raising those bars which had been unduly lowered and scouring out those which were abnormally high. They should also, to a certain extent, enlarge the river section, but at a rate so low that it would be a question of practical importance to those who will inhabit the valley in the twenty-fifth century, rather than those who are tilling it to-day.

### LEVEE HEIGHTS.

While there is no evidence that the bed of the Mississippi River has risen from levee construction, it is apparent that flood heights have greatly increased in the last 20 years.

When the Mississippi River Commission was formed there existed two schools of engineers—one that believed if the river were leveed it would scour out so that a large increase in flood heights would not occur; the other that there would be little enlargement of the river section, and that flood heights should be computed without regard thereto.

There was considerable discussion of those propositions, both by the commission and the general public, and the general public was very strongly opposed to the theory that high levees were necessary.

I take the liberty of recalling that about 20 years ago I submitted a paper to prove that if the St. Francis Basin were leveed a flood like that of 1882 would attain a height at Helena of at least 54 feet. I was forthwith charged with being an enemy of the levee system. A state of the public mind existed similar to that which arose in Louisiana at the commencement of the recent flood, when I intimated that there was danger to the levees of that State. I do not recall that any demands were made for my removal, but it was suggested to the commission that investigations by subordinate officers be discouraged.

Under these conditions it was necessary for the commission to establish a grade line for levee construction, and they announced a provisional grade, which was neither as low as many persons considered ample, nor as high as others thought necessary. This grade was generally accepted as a line to build to, the ultimate grade to which levees were to be constructed to be afterwards determined by observation.

This was a most happy solution of the problem, as was forcibly demonstrated during the last flood, during which less than 1 per cent of the length of the levee line was destroyed. The engineer must always bear in mind that he must make the best use that is possible of the funds with which he is intrusted. If the ultimate grade line which this flood shows is necessary had been adopted, it is true that many miles of levee would have been held with comparatively little effort, as was the case in the upper Yazoo district, but to attain such a result the funds which would have been expended

in constructing them would have been taken from the remainder of the levee line, which would have been necessarily weakened thereby, and crevasses would therefore have been much more frequent.

In fact, if it could be predicted that the next great flood would be similar to the last, even a somewhat lower provisional grade line would be desirable in certain portions of the river, as 586 miles of levees have not been constructed to this grade, and some 53,000,000 cubic yards must be placed in them to create the cross section which has been adopted by the commission. But no two floods are similar. The grade line established by this flood will be subject to material changes, arising from variations in the discharge of the White, Arkansas, and Red Rivers, or even from local rains.

There is appended a table which gives the heights attained by the river at various localities during the last flood, the previous highest waters, the provisional levee grade, and the estimated high water during the flood of 1912 if no crevasses had occurred. It will surprise many to learn that at none of the stations in the table the flood of 1912 reached a height equal to that of the provisional grade line, nor did a crevasse occur in any levee that was built to the grade and given the cross section established by the commission, except possibly at Hymelia.

If the recommendations of the commission, made some 15 years ago, had been carried out, this disaster, to a large extent, would have been averted. I do not mean to imply by this statement that the provisional grade adopted by the commission is the ultimate grade to which levees should be constructed; in fact, they must ultimately be built at least from 2 to 3 feet higher; but that if the provisional grade and cross-section had existed throughout the valley, wherever the flood attained a height greater than the provisional grade, there would have been a good fighting chance to hold the levees by topping, while with defective foundations and weak section, the battle was lost before the river could attain that height.

As a result of this flood the commission does not recommend any immediate change in its provisional grade; on the contrary, it is of the opinion that the first work to be done is to strengthen the foundations wherever any weakness has been observed, then to bring the section to standard dimensions. When the levee line is uniformly perfected to the provisional grade, its further enlargement will be advisable. Excessive strength in one locality with the necessary undue weakness at others should be avoided.

## CAVING BANKS.

While about 2,500,000 cubic yards of the levee line were destroyed by crevasses during the last flood, over 4,300,000 cubic yards had to be abandoned during the past year on account of caving banks. The loss from crevasses is considered a national calamity, while that from caving banks is scarcely noticed. But I desire to particularly invite attention to the drain upon the community this caving of levees into the river has become. It requires an expenditure of nearly $1,000,000 annually to replace them. The Mississippi River Commission appreciates the relief that Congress has afforded them by its proviso that $4,000,000 of the $6,000,000 appropriated by the last rivers and harbors bill must be expended on levees. It precludes the

use of any funds for the protection of city parks or even city fronts. But there is a danger from too close a limitation of the powers of the commission. It frequently is cheaper to construct a bank revetment than to rebuild a levee which is caving into the river. I apprehend that under the present act several hundred thousand dollars will be wasted. Because of its limitations levees must be constructed where bank revetments are more desirable.

### FOUNDATIONS.

The advice which the commission has received on the use of concrete, steel piles, triple-lap sheet piling, and other patent inventions for levee construction, would fill a large volume. I will not detain you with a discussion of these devices further than to state that we are convinced from the results of the late flood that greater care must be exercised in securing the levee foundations, but whether this result will be attained by an enlarged muck ditch, a wall of concrete or sheet piling, or other means, is dependent so much on local conditions that no general plan can at present be formulated.

### CONCLUSION.

The flood of 1912 affords no argument for the abandonment of levee construction. It has simply attained the height which Gen. Comstock and Maj. Starling predicted the flood of 1882 would have attained if the river had then been confined. It has cleared the atmosphere of certain false theories, and we can now resume operations with a definite knowledge of the problem before us. We are passing through the same experience European nations have had. Levees have been tested for ages and have proved uniformly successful when built of adequate dimensions. During the progress of construction there were disasters on foreign rivers as well as in the United States. No other method of relief from floods has been successfully applied to large streams.

Originality is a very desirable quality in an engineer, but there is danger of confusing originality and ignorance. When a proposition with which he is unfamiliar is presented to him it is his duty to follow the instructions placed at some railway crossings, to stop, look, and listen. He should investigate what has been done in the past, and seek to discover if there is no precedent for his action.

It was said several thousand years ago that there is nothing new under the sun. The saying is true to-day. To adopt a project, even though popular, that has been tried, found wanting, and rejected by our forefathers, is not progress, but retrogression.

*Table of gauge readings of flood heights and provisional grades, Mississippi River, Cairo to Fort Jackson.*

| Name of gauge station. | Miles below Cairo. | High water, 1912.[1] | | Previous highest water and year. | | High water, 1912, compared with previous highest. | Estimated high water for confined flood, 1912.[2] | Provisional levee grade. | High water, 1912, below provisional levee grade. |
|---|---|---|---|---|---|---|---|---|---|
| | | Date. | Gauge reading. | Feet. | Year. | | | | |
| | | | *Feet.* | | | *Feet.* | *Feet.* | *Feet.* | *Feet.* |
| Cairo, Ill | 0.0 | Apr. 6, 7 | 53.95 | 52.17 | 1883 | +1.78 | 55.0 | 55.20 | 1.25 |
| Columbus, Ky | 21.6 | Apr. 5 | 49.00 | 45.58 | 1883 | +3.42 | 49.7 | 51.30 | 2.30 |
| New Madrid, Mo | 70.3 | ....do | 44.11 | 40.27 | 1897 | +3.84 | 44.6 | 45.60 | 1.49 |
| Cottonwood Point, Mo | 122.5 | Apr. 11–13 | 42.04 | 39.96 | 1903 | +2.08 | 43.0 | 44.30 | 2.26 |
| Fulton, Tenn | 175.4 | Apr. 9 | 43.31 | 40.15 | 1903 | +3.16 | 44.0 | 44.60 | 1.29 |
| Memphis, Tenn | 230.0 | Apr. 6 | 45.20 | 40.30 | 1907 | +4.90 | 48.5 | 45.60 | .40 |
| Mhoon Landing, Miss | 276.3 | ....do | 44.90 | 42.20 | 1907 | +2.70 | 47.0 | 46.80 | 1.90 |
| Helena, Ark | 306.5 | Apr. 22 | 54.30 | 51.75 | 1897 | +2.55 | 55.5 | 56.10 | 1.80 |
| Sunflower Landing, Miss | 352.7 | Apr. 15 | 50.85 | 48.00 | 1903 | +2.85 | 53.0 | 52.20 | 1.35 |
| Mouth of White River, Ark | 393.2 | Apr. 16 | 56.35 | 53.70 | 1903 | +2.65 | 58.9 | 57.70 | 1.35 |
| Arkansas City, Ark | 438.3 | Apr. 12 | 55.35 | 52.90 | 1903 | +2.45 | 57.5 | 56.90 | 1.55 |
| Greenville, Miss | 478.3 | ....do | 50.75 | 49.10 | 1903 | +1.65 | 52.8 | 53.10 | 2.35 |
| Lake Providence, La | 542.3 | ....do | 48.11 | 46.48 | 1903 | +1.63 | 50.7 | 50.48 | 2.37 |
| Vicksburg, Miss | 599.3 | ....do | 51.65 | 52.48 | 1897 | —0.83 | 55.0 | 55.80 | 4.15 |
| St. Joseph, La | 648.3 | Apr. 13 | 48.60 | 48.07 | 1903 | +0.53 | 51.0 | 52.80 | 4.20 |
| Natchez, Miss | 700.3 | Apr. 13, 17 | 51.40 | 50.35 | 1903 | +1.05 | 54.5 | 56.00 | 4.60 |
| Red River Landing, La | 765.3 | May 11, 12 | 53.20 | 50.20 | 1897 | +3.00 | 54.5 | 54.50 | 1.30 |
| Bayou Sara, La | 799.8 | May 11 | 47.20 | 43.70 | 1897 | +3.50 | 48.5 | 47.70 | .50 |
| Baton Rouge, La | 833.3 | May 11, 13 | 43.80 | 40.65 | 1897 | +3.15 | 45.1 | 45.20 | 1.40 |
| Plaquemine, La | 854.1 | May 11 | 39.38 | 36.25 | 1897 | +3.13 | 40.7 | 40.70 | 1.32 |
| Donaldsonville, La | 885.4 | May 10 | 35.10 | 32.75 | 1897 | +2.35 | 36.0 | 36.95 | 1.85 |
| College Point, La | 904.5 | May 11 | 30.23 | 27.95 | 1897 | +2.28 | 31.4 | 31.80 | 1.57 |
| Carrollton, La | 957.0 | ....do | 21.05 | 19.42 | 1903 | +1.63 | 22.2 | 23.00 | 1.95 |
| Fort Jackson, La | 1,039.0 | May 3, 4, 7, 11 | 8.28 | 8.27 | 1907 | +0.01 | 9.0 | 11.00 | 2.72 |

[1] The high water of 1912 is the highest known for all stations on the Mississippi River from Cairo down, except at Vicksburg, Miss.
[2] The estimated high water for the 1912 flood confined is deduced from the data now available, and may be modified by further experience.

## THE PROBLEM OF THE MISSISSIPPI RIVER.

The great flood of the Mississippi River of last year—the largest in recorded history—when the levees were overtopped or carried away bodily, and vast areas of the valley were inundated, has created a doubt in the minds of the public as to whether the method of control by revetment and construction of levees was not a failure. This doubt has been freely expressed in the many letters which have been published during the past year in the columns of the Scientific American. We have made no comment upon these letters, many of which suggested alternative and supposedly better plans for the control of the river, and our silence has been due to the fact that we were making a study of the problem from every possible source of information, with a view to determining for ourselves whether the present plans for the control of the river, or some other, were the best to apply in grappling with and controlling this stupendous problem.

We have come to the conclusion that the present plan of the Army Engineers of protecting the banks of the river by revetment and raising the banks by artificial levees to a sufficient height to prevent overflow is not only the best way to control the river, but the only way.

If it be asked whether the disastrous inundation of last year does not spell failure, we answer emphatically, "No." The inundation occurred, not because the plan was faulty, but because it was incomplete. It was also due to the fact that the existing levees were built only to a sufficient elevation to control the highest flood on record, which the flood of last year greatly exceeded—the maximum flow reaching the enormous total of 2,300,000 feet per second, or 12 times the amount of water that passes over Niagara Falls.

The trouble with the Mississippi work is not that the plans are wrong, but that they have been carried out piecemeal, and in a somewhat happy-go-lucky manner. The Nation should apply to this great work the lesson which it has learned at Panama. A new grade line for the summit of the levees should be established, said line being well above the height reached by the flood of last year; a liberal estimate should be made of the total cost of building these levees, and of protecting the adjacent banks of the river throughout the whole length of the levees with revetments; an estimate should be made of the largest annual appropriation of money that could be efficiently expended by the largest force that could be concentrated upon the work; and finally the execution of the work should be placed entirely in the hands of the Army Engineers with a Col. Goethals in supreme and unhampered control.

Such an estimate of the total cost of a completely leveed and revetted Mississippi River has been made by the Army engineers under the Mississippi River Commission. The total expenditure would be

about $70,000,000 for the levee work and about $90,000,000 for the revetment.

Is complete control of the Mississippi River and the absolute prevention of disastrous floods worth the expenditure of $160,000,000? The Scientific American is decidedly of the opinion that the money would be well spent. In the first place, the completion of this work would afford protection to 29,000 square miles of land. The increased value of the land, due to protection, is shown by a statement of Col. Townsend, president of the Mississippi River Commission, who has recently testified before the Committee on Rivers and Harbors in the House of Representatives that 20 years ago, when he was first stationed in the St. Francis Basin, land in that vicinity could be bought for a dollar or two an acre, whereas to-day it is worth anywhere from $20 to $50 and even $100 an acre. Furthermore, there is the humanitarian consideration that this work would prevent the great loss of life and destruction of property which occurs when the river breaks loose. And, finally, there is the consideration that the completion of this task will constitute a great national work of engineering comparable, in its magnitude and beneficent results, with the execution of the Panama Canal.

We will now proceed to discuss the criticisms of the present plan and the suggestions of alternative schemes of control which have been made in the many letters referred to above. It has been stated that the whole principle of levee building is wrong; and this for the reason that the matter brought down in suspension is deposited along the bed of the river, which is continually being raised, that this necessitates a raising of the levees, which must go on indefinitely. As a matter of fact, what takes place is this: When the floods come down, the deep pools are scoured out and the material is deposited on the shoals farther down the river, causing a temporary raising of the bottom at these points. As the river falls, the action is reversed, the bars are scoured out, and the sand is deposited in the next pool. Careful surveys for several decades show that not only has there been no raising of the river bed, but the cross section of the river has slightly increased.

As to the proposal to control the Mississippi by building vast reservoirs near the headwaters of the river and its tributaries, it may be said at once that the magnitude and cost of such reservoirs and the enormous areas of land that would have to be condemned, render such a scheme impracticable. Its advocates have failed to realize the stupendous magnitude of a problem which involves the control of flood waters that sweep down the Mississippi River at the rate of 2,300,000,000 cubic feet per second. Testifying on the point, Col. Townsend said before the House Committee: "If you were to destroy the whole State of Minnesota—that is, stop every bit of water flowing over it—it would not have made a difference of three-tenths of a foot in the height of the last flood at Cairo." Again, if, as has been suggested, the St. Francis Basin were converted into a storage reservoir and the floods were thereby reduced 3 or 4 feet in height, it would be necessary to sacrifice no less than 7,000 square miles of country, or the area of a good-sized State.

Another favorite scheme contemplates the diversion of the Mississipp or of a large portion of its flood waters, by means of subchannels, or "canals," excavated on one side or the other of the river. This

suggestion also fails to appreciate the magnitude of the problem. If such channels were to be cut, they would have to be leveed in exactly the same way as the river which they were intended to relieve. To produce any serious diminution in the height of a river that was passing down 2,300,000,000 cubic feet of water per second, it would be necessary to divert from 400,000 to 600,000 feet per second; which means that an artificial river would have to be excavated and leveed whose flow would be from two to three times as great as the whole flow of the Niagara River.

The proposition to straighten out the river by cutting through the bends is impracticable for the reason that while the more rapid flow would relieve the flood in the districts thus affected, this relief would be obtained at the expense of the districts lower down the river. The swifter current of the flood water, due to the shorter course, would necessitate a corresponding increase in the height of the levees in the lower sections of the valley.

As to the important question of financing the work, the simplest and most effective plan, of course, would be to do with regard to the Mississippi as we have done at Panama—make it a national problem and provide the whole cost from the National Treasury. Hitherto the Government has put up so much money; so much has been contributed by the local levee boards; and in one case, at least, the State has made appropriations. It is not surprising to learn that Col. Townsend designates such conditions as amounting to practically "an absence of system." Says he: "We have just simply been waiting, each one doing the best he could—the levee boards have been doing their work, and the district engineers have been doing whatever they could with their funds, and it has been a happy-go-lucky method of business."

We believe that the most satisfactory way of financing the project would be for Congress to treat the improvement of America's greatest river as a national undertaking, make the necessary appropriations, abolish the system of individual boards, and place the execution of the work under the one-man control of the Army. Next to this the best plan would be one of joint Federal and State appropriations, in proportions to be determined by the local advantages secured; with the physical design and execution of the work intrusted to the Corps of Engineers of the Army, working under the absolute control of an Army officer of proved executive ability.

In another year the Panama Canal will be completed. Why not move Col. Goethals with his admirable staff and perfectly working system from the Isthmus of Panama to the Mississippi Valley?

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